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Materials and Manufacturing Directorate

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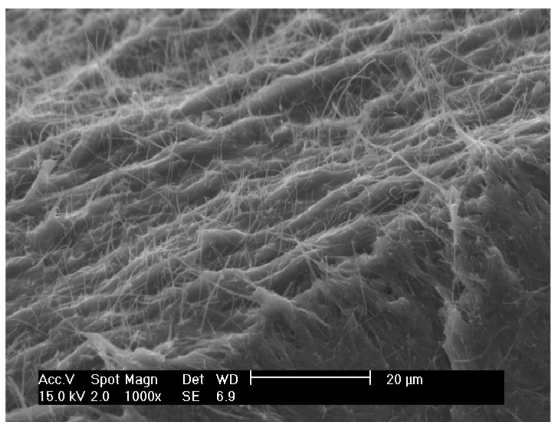
Nanoscience and Technology for Materials

The nano-scale, and associated excitement surrounding nanoscience and technology (NST), affords unique opportunities to create revolutionary material combinations. These new materials will enable the circumvention of classic material performance trade-offs by accessing new properties and exploiting unique synergism between materials that only occur when the length-scale of morphology and the fundamental physics associated with a property coincide – i.e. on the nanoscale! The confluence of fundamental understanding of materials at this scale and the realization of fabrication and processing techniques that provide simultaneous structural control on the nano-, as well as micro- and macro-, length scales is the core of the exciting area of *nano-engineered materials.*



Nanoscience and nanotechnology are not just another step towards miniaturization, but exploration and utilization of a new scale that qualitatively provides new phenomena. At the heart is the possibility of observing, and ultimately manipulating, new properties and behavior not anticipated from micronscale counterparts or constituent atoms, but unique to the nanoscale assemblage of atoms and the subsequent arrangement of these assemblages. Developing techniques to synthesize, fabricate, characterize, manipulate and assemble and elucidate the fundamental structure-property relationships of these units are the central tenant of nanoscience and nanofabrication.

The term, "nanomaterial" is often used to encompass the wide range of nano-scale and nanostructured materials necessary to enable these technologies, including structural and functional applications. At one extreme are bulk materials that are specially processed to develop a nanostructure of some form, for example, nanocrystallinity. At the other extreme are materials for which the focus is upon "individual" nanoscale units, such as nanoparticles, nanoclusters and supra-molecular structures. In between are a vast number of potential materials that combine different components in a wide variety of form and arrangement, so called nano-composites.

In general what distinguishes a "nanomaterial" from its chemically identical "conventional" counterpart is not just having a feature on the nanoscale, but rather the breakdown of scaling laws. This means that one or more properties are (radically) different from what would be expected from a simple extrapolation of the properties of the material in the bulk and microscale region (above about 0.1 micrometer) down to nanometer scales. This aspect alone offers for the addition of a new property space that enables a new trade space for the optimization of previously contradictory material performance parameters. In addition, as with other materials, it is often possible to tune the properties by manipulating the processing route. The combination of this new property space opened up through the nanoscale with multiple processing routes provides for a wealth of new material behaviors and manipulations. For the emerging supra-molecular nanomaterials, there are no conventional counterparts, and the target properties are radical from the outset. Here in particular there is huge potential for tailoring the material to obtain specific properties.

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